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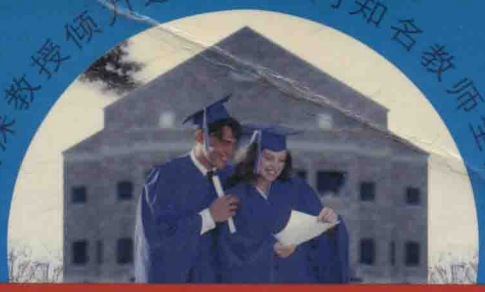


国外高校电子信息类优秀教材

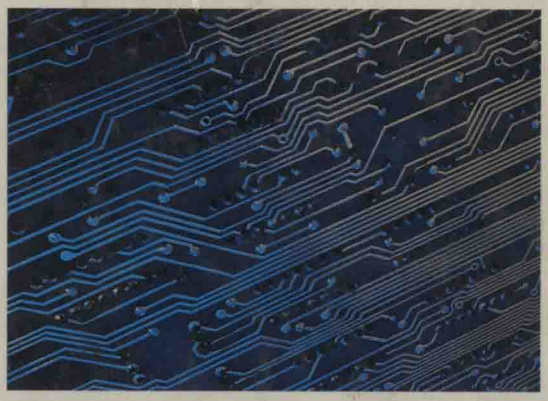
数字基础

（第七版）

Digital Fundamentals

(Seventh Edition)

（英文影印版）



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内 容 简 介

本书为国外高校电子信息类优秀教材(英文影印版)之一。

本书全面论述了数字电路设计的基础知识,包括数字电路概念、数字系统运作及规划、逻辑门、布尔数学运算和逻辑简化、组合逻辑电路及其功能、可编程逻辑器件、触发器、计数器、移位记录器、PLD 的时序逻辑器件及其记忆和存储界面等。

本书还将教会学生使用 EWB 软件,掌握虚拟测试技术。

本书适用于高等院校电气工程、电子信息工程、机电工程及相关专业本科生,也可供一般工程技术人员参考。

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PREFACE

This seventh edition of *Digital Fundamentals* provides a comprehensive coverage in a clear, concise, well-illustrated format. As in previous editions, this one contains a balanced treatment of basic concepts, up-to-date technology, practical applications, and troubleshooting. In this edition, many topics have been strengthened or enhanced and numerous improvements are reflected throughout the book. Also, some completely new features have been added, including Electronics Workbench (EWB) exercises, Computer Notes, and Hands-On Tips. This edition has been carefully reviewed and checked to ensure up-to-date accurate coverage.

Most likely, you will find more topics than can be covered in one term. This extensive range of topics provides flexibility to accommodate a variety of technology programs. For example, some of the mathematical, design-oriented, or system application topics may not be appropriate for certain programs. Other programs may not cover PLDs or may not require an introduction to microprocessors. Many programs cover the circuit details of integrated circuits while others do not deal with component-level topics at all. These topics can be omitted or lightly covered without affecting other coverage. A background in transistor circuits is not a prerequisite for this text.

New to This Edition

In addition to general updating and improvements in text and graphics throughout the book, the seventh edition includes the following new features.

Electronics Workbench (EWB) Tutorials There is a Website tutorial associated with many chapters in the text that can be downloaded for student use. These tutorials introduce aspects and elements of EWB as needed on a chapter by chapter basis and also contain examples and exercises. These tutorials may be found at *http://www.prenhall.com/floyd.*

System Application EWB Simulation For many System Applications in the text, the circuit board logic is simulated in EWB and is available on the CD-ROM accompanying the textbook. To observe the circuit in operation for a given System Application, the reader simply opens the specified file, connects any necessary EWB instruments, and runs the simulation. The CD-ROM contains free Electronics Workbench Demonstration software. The full version of EWB software is also on the CD-ROM, with access available for a fee.

EWB Troubleshooting Problems At the end of most chapters, new troubleshooting problems reference circuits on the CD-ROM. Generally, these circuits have hidden faults, and students must use troubleshooting techniques to identify the faults. In some cases, the circuits do not have faults and are working properly, and the student must determine this also. Results can be found in the Instructor's Resource Manual (IRM).

Computer Notes This feature provides interesting and instructional information about computer technology as it relates to text coverage. These optional Computer Notes, identified by a special logo and design treatment, are found throughout the book, and most chapters have one or more.

Hands-On Tips Called "HOTip" for short, this feature provides useful and practical information interspersed throughout the book. HOTips are identified by a special logo and design treatment. They generally relate to the text coverage but can be skipped over without affecting the instructor's presentation and students' understanding of the material.

Other new or improved features include

- Key term list at the end of each chapter
- General revisions and improvements throughout
- Revised calculator tutorials using the TI-85 calculator
- Revised coverage of integrated circuit logic gates in Chapter 3
- Revised coverage of memories and storage devices in Chapter 12
- Revised coverage of standard buses in Chapter 13
- Revised coverage of microprocessors and computers in Chapter 14

Additional Features

- Full-color format
- Two chapters on PLDs (Chapters 7 and 11)
- Unique "floating chapter" concept with Chapter 15 provides optional coverage of IC technology at any point.
- Overview and objectives at the opening of each chapter
- Introduction and objectives at the beginning of each section within a chapter
- Review questions at the end of each section in a chapter
- Related Problem in each worked example
- Digital System Applications sections at the end of most chapters
- Chapter summaries
- Multiple-choice self-test at the end of each chapter
- Extensive sectionalized chapter problem sets
- Comprehensive glossary at the end of the book

Improved Ancillary Package

- Two lab manuals: *Experiments in Digital Fundamentals,* Fifth Edition, by David Buchla, and *Digital Experiments Emphasizing Troubleshooting,* Fifth Edition, by Jerry Cox
- EWB exercise CD-ROM accompanying the lab manual by David Buchla
- Instructor's Resource Manual with solutions to end-of-chapter problems and System Applications, worksheet masters, introduction to CUPL, and electronics standards
- Test Item File (hard copy)
- Prentice Hall Custom Test (electronic testbank copy)
- PowerPoint slides
- Bergwall Video

Illustration of the Chapter Features

Chapter Opener Each chapter begins with a two-page spread, as shown in Figure P–1. The left page includes a list of the sections in the chapter, a list of chapter objectives, and a website reference for the EWB tutorial. The right page has an overview of the chapter, a list of specific devices introduced in the chapter (each new device is indicated by an IC logo at the point where it is introduced), and a brief description of the Digital System Application with related art.

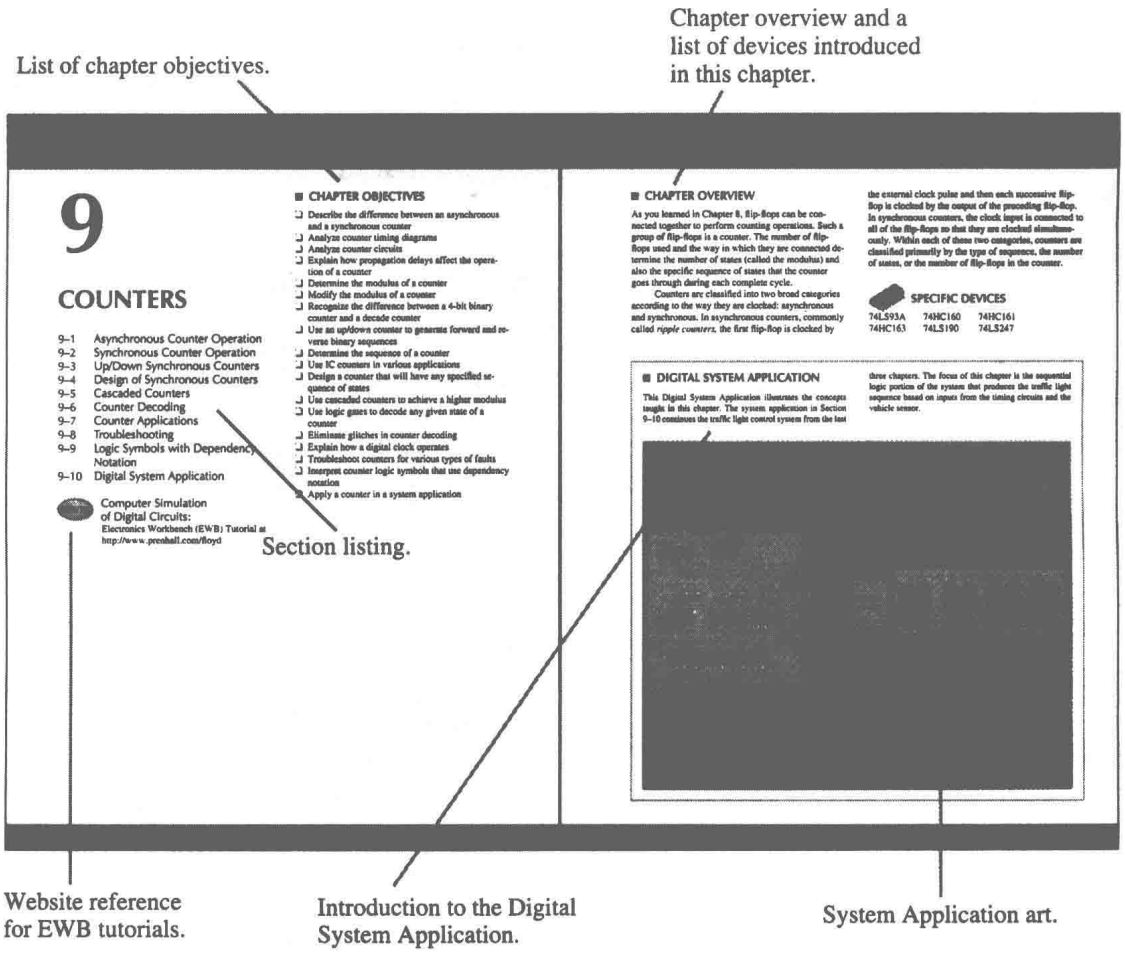


FIGURE P–1
Chapter opener.

Section Opener Each of the sections in a chapter begins with a brief introduction that includes a general overview and section objectives. An example is shown in Figure P–2.

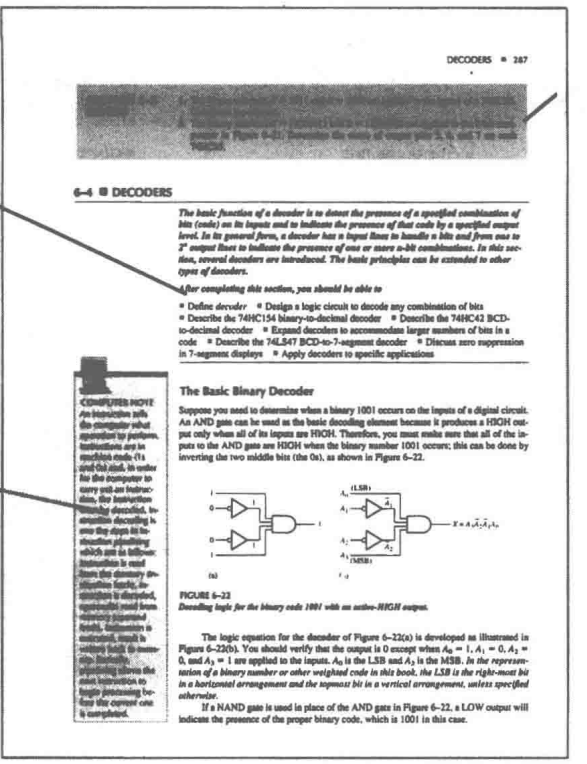
Section Review Each section ends with a review consisting of questions or exercises that emphasize the main concepts presented in the section. This is shown in Figure P–2. Answers to the Section Reviews are at the end of the chapter.

Worked Examples and Related Problems Numerous worked examples help illustrate and clarify basic concepts or specific procedures. Each example concludes with a Related Problem that reinforces or expands on the example. Some Related Problems require a repetition of the example using different parameters or conditions. Others focus on a more limited part of the example or encourage further thought. A typical worked example and Related Problem are shown in Figure P–3. Answers to Related Problems are at the end of the chapter.

Troubleshooting Section Many chapters include a troubleshooting section that relates to the topics covered in the chapter and that emphasizes troubleshooting techniques and the use of test instruments. A portion of a typical troubleshooting section is illustrated in Figure P–4 on page vii.

Digital System Application The last section of most chapters presents a practical application of the concepts and devices covered in the chapter. Each of these sections presents a real-world system in which analysis, troubleshooting, and design elements are

FIGURE P–2
Section opener and section review.



DECODERS ■ 287

6–6 ■ DECODERS

The basic function of a decoder is to detect the presence of a specified combination of bits (code) on its inputs and to indicate the presence of that code by a specified output level. In its general form, a decoder has n input lines to handle n bits and from one to 2^n output lines to indicate the presence of one or more n-bit combinations. In this section, several decoders are introduced. The basic principles can be extended to other types of decoders.

After completing this section, you should be able to

■ Define *decoder* ■ Design a logic circuit to decode any combination of bits ■ Describe the 74HC154 binary-to-decimal decoder ■ Describe the 74HC42 BCD-to-decimal decoder ■ Expand decoders to accommodate larger numbers of bits in a code ■ Describe the 74LS47 BCD-to-7-segment decoder ■ Discuss zero suppression in 7-segment displays ■ Apply decoders to specific applications

COMPUTER NOTE
An instruction tells the computer what operation to perform. Instructions are in machine code (1's and 0's), in order for the computer to carry out an instruction, the instruction must be decoded. Instruction decoding is one of the steps in instruction processing which are to follow. Instruction is read from the memory, an instruction is executed, operand(s) read from memory (operand fetch), instruction is executed, result is usually held in memory. Typically, processing starts the next instruction or begin processing before the current one is completed.

The Basic Binary Decoder

Suppose you need to determine when a binary 1001 occurs on the inputs of a digital circuit. An AND gate can be used as the basic decoding element because it produces a HIGH output only when all of its inputs are HIGH. Therefore, you must make sure that all of the inputs to the AND gate are HIGH when the binary number 1001 occurs; this can be done by inverting the two middle bits (the 0s), as shown in Figure 6–22.

(a)

FIGURE 6–22
Decoding logic for the binary code 1001 with an active-HIGH output.

The logic equation for the decoder of Figure 6–22(a) is developed as illustrated in Figure 6–22(b). You should verify that the output is 0 except when $A_0 = 1$, $A_1 = 0$, $A_2 = 0$, and $A_3 = 1$ are applied to the inputs. A_0 is the LSB and A_3 is the MSB. *In the representation of a binary number or other weighted code in this book, the LSB is the right-most bit in a horizontal arrangement and the topmost bit in a vertical arrangement, unless specified otherwise.*

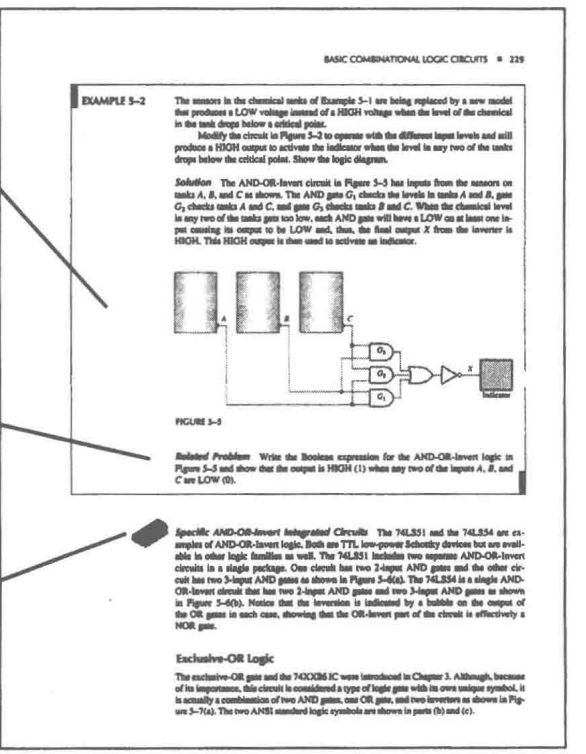
If a NAND gate is used in place of the AND gate in Figure 6–22, a LOW output will indicate the presence of the proper binary code, which is 1001 in this case.

Review exercises end each section.

Introductory paragraph and a list of performance-based section objectives begin each section.

Computer Notes are found throughout the text (not part of section opener).

FIGURE P–3
An example and related problem.



BASIC COMBINATIONAL LOGIC CIRCUITS ■ 229

EXAMPLE 5–2

The sensors in the chemical tanks of Example 5–1 are being replaced by a new model that produces a LOW voltage instead of a HIGH voltage when the level of the chemical in the tank drops below a critical point.

Modify the circuit in Figure 5–2 to operate with the different input levels and still produce a HIGH output to activate the indicator when the level in any two of the tanks drops below the critical point. Show the logic diagram.

Solution The AND-OR-Invert circuit in Figure 5–3 has inputs from the sensors on tanks *A*, *B*, and *C* as shown. The AND gate G_1 checks the levels in tanks *A* and *B*, gate G_2 checks tanks *A* and *C*, and gate G_3 checks tanks *B* and *C*. When the chemical level in any two of the tanks gets too low, each AND gate will have a LOW on at least one input causing its output to be LOW and, thus, the final output *X* from the inverter is HIGH. This HIGH output is then used to activate an indicator.

FIGURE 5–3

Related Problem Write the Boolean expression for the AND-OR-Invert logic in Figure 5–3 and show that the output is HIGH (1) when any two of the inputs *A*, *B*, and *C* are LOW (0).

Specific AND-OR-Invert Integrated Circuits The 74LS51 and the 74LS54 are examples of AND-OR-Invert logic. Both are TTL low-power Schottky devices but are available in other logic families as well. The 74LS51 includes two separate AND-OR-Invert circuits in a single package. One circuit has two 2-input AND gates and the other circuit has two 3-input AND gates as shown in Figure 5–6(a). The 74LS54 is a single AND-OR-Invert circuit that has two 2-input AND gates and two 3-input AND gates as shown in Figure 5–6(b). Notice that the inversion is indicated by a bubble on the output of the OR gates in each case, showing that the OR-Invert part of the circuit is effectively a NOR gate.

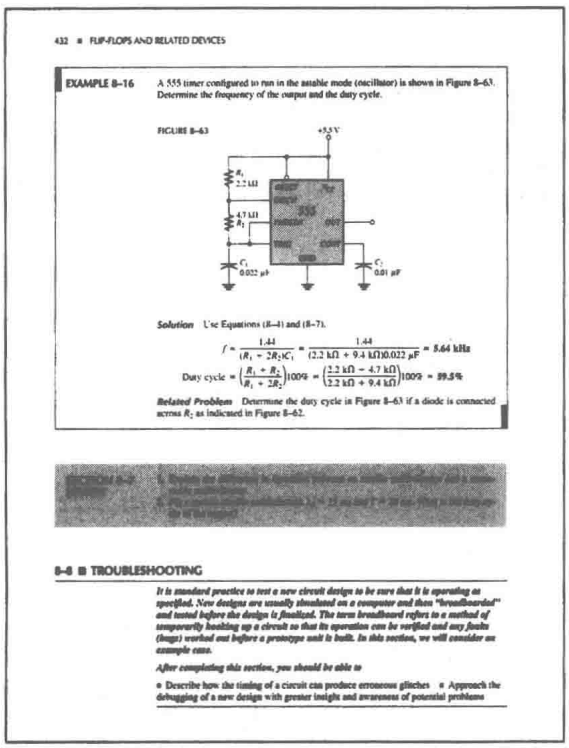
Exclusive-OR Logic

The exclusive-OR gate and the 74XX86 IC were introduced in Chapter 3. Although, because of its importance, this circuit is considered a type of logic gate with its own unique symbol, it is actually a combination of two AND gates, one OR gate, and two inverters as shown in Figure 5–7(a). The two ANSI standard logic symbols are shown in parts (b) and (c).

Each example is contained within a ruled box.

Each example contains a problem related to the example.

IC icon indicates introduction to new devices.



432 ■ FLIP-FLOPS AND RELATED DEVICES

EXAMPLE 8–16 A 555 timer configured to run in the astable mode (oscillator) is shown in Figure 8–63. Determine the frequency of the output and the duty cycle.

FIGURE 8–63

Solution Use Equations (8–4) and (8–7).

$$f = \frac{1.44}{(R_1 + 2R_2)C_1} = \frac{1.44}{(2.2\text{ k}\Omega + 9.4\text{ k}\Omega)0.022\ \mu\text{F}} = 5.64\text{ kHz}$$

$$\text{Duty cycle} = \left(\frac{R_1 + R_2}{R_1 + 2R_2}\right)100\% = \left(\frac{2.2\text{ k}\Omega + 4.7\text{ k}\Omega}{2.2\text{ k}\Omega + 9.4\text{ k}\Omega}\right)100\% = 89.5\%$$

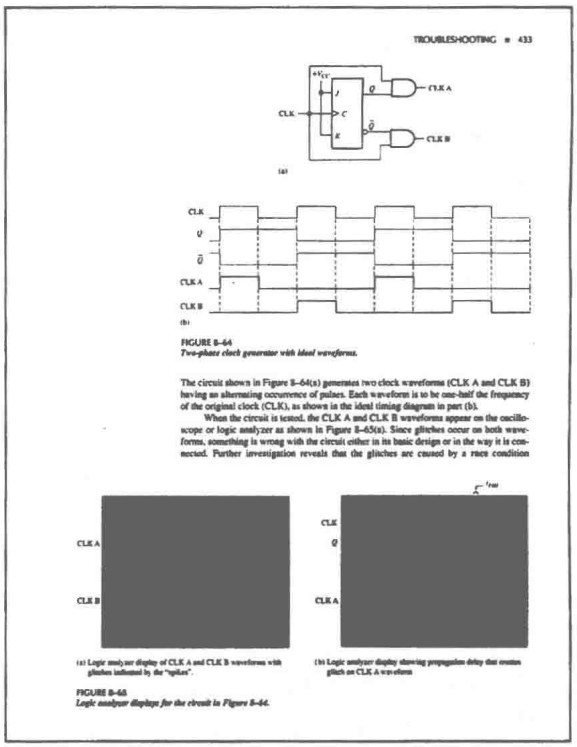
Related Problem Determine the duty cycle in Figure 8–63 if a diode is connected across R_2 as indicated in Figure 8–62.

8–6 ■ TROUBLESHOOTING

It is standard practice to test a new circuit design to be sure that it is operating as specified. New designs are usually simulated on a computer and then "breadboarded" and tested before the design is finalized. The term breadboard refers to a method of temporarily hooking up a circuit so that its operation can be verified and any faults (bugs) worked out before a prototype unit is built. In this section, we will consider an example case.

After completing this section, you should be able to

- Describe how the timing of a circuit can produce erroneous glitches
- Approach the debugging of a new design with greater insight and awareness of potential problems



TROUBLESHOOTING ■ 433

FIGURE 8–64
Two-phase clock generator with ideal waveforms.

The circuit shown in Figure 8–64(a) generates two clock waveforms (CLK A and CLK B) having an alternating occurrence of pulses. Each waveform is to be one-half the frequency of the original clock (CLK), as shown in the ideal timing diagram in part (b).

When the circuit is tested, the CLK A and CLK B waveforms appear on the oscilloscope or logic analyzer as shown in Figure 8–65(a). Since glitches occur on both waveforms, something is wrong with the circuit either in its basic design or in the way it is connected. Further investigation reveals that the glitches are caused by a race condition

(a) Logic analyzer display of CLK A and CLK B waveforms with glitches indicated by the "spikes".

(b) Logic analyzer display showing propagation delay that creates glitch on CLK A waveform

FIGURE 8–65
Logic analyzer displays for the circuit in Figure 8–64.

FIGURE P–4
Representative pages from a portion of a typical Troubleshooting section.

implemented in a series of activities called *System Assignments.* Some System Applications are limited to a single chapter, and others extend over two or more chapters. Specific Digital System Applications and the chapters in which they appear are as follows:

- Tablet counting and control system: Chapters 1, 2, 3, and 4
- Digital motor control system: Chapter 5
- Traffic light control system: Chapters 6, 7, 8, 9, and 11
- Security entry system: Chapters 10 and 12
- Satellite antenna positioning system: Chapter 13

Although they are not intended or designed for use as laboratory projects (except the laboratory of the mind), many of the System Applications utilize realistic representations of printed circuit boards and instruments to provide experience in relating schematics to actual boards, identifying IC packages, and obtaining data from certain instrument readings and displays. Because their omission will not affect any other material in the text, System Applications may be treated as optional. Figure P–5 shows a portion of a Digital System Application section.

Chapter End Matter The following study aids end each chapter:

- Chapter Summary
- Key Terms
- Self-Test
- Problem set that includes some or all of the following categories: Basic problems, Troubleshooting problems, System Application problems, Design problems, and EWB Troubleshooting problems.
- Answers to Section Reviews
- Answers to Related Problems for Examples
- Answers to Self-Test

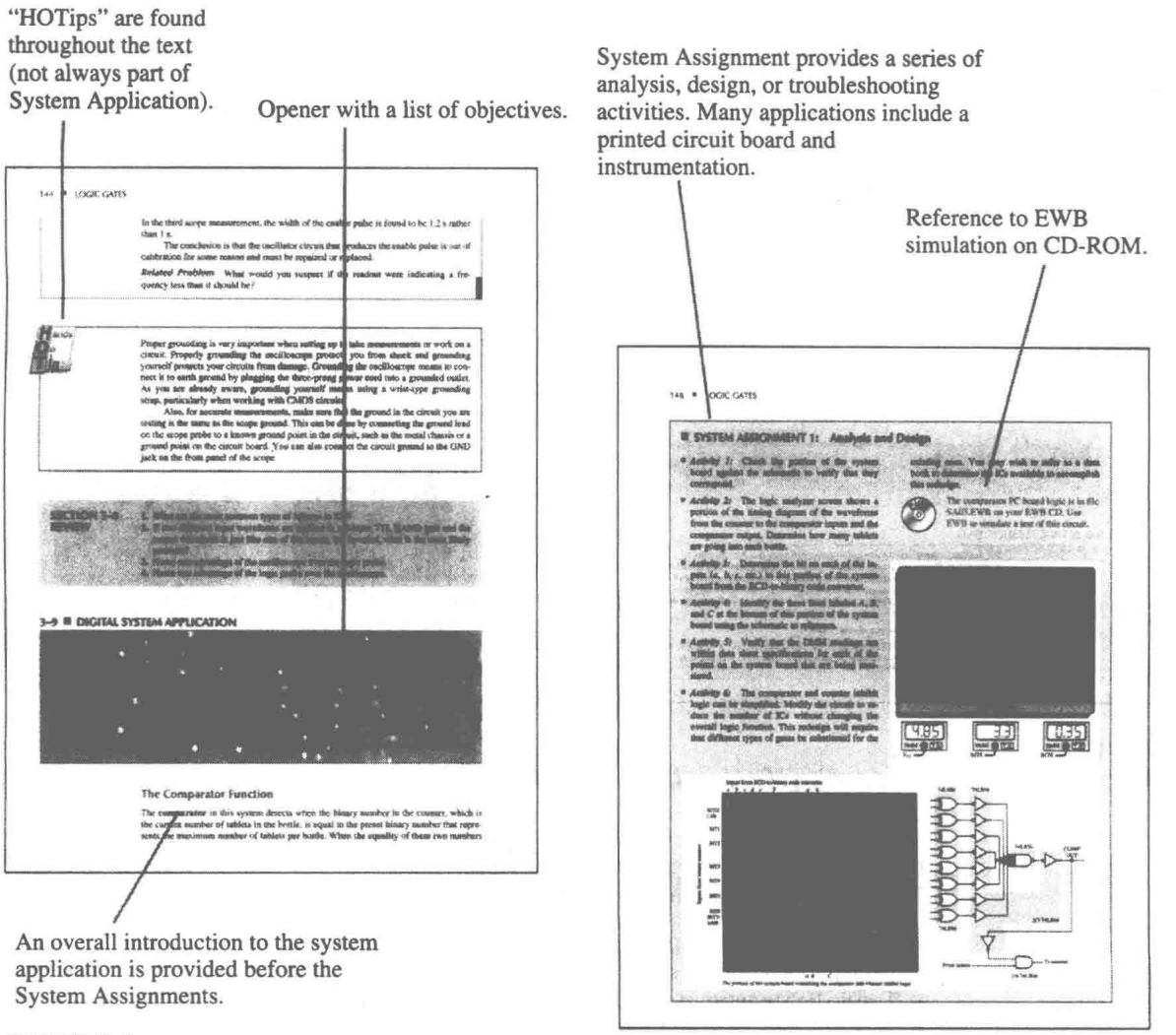


FIGURE P–5

Representative pages from a typical Digital System Application section.

Content and Organization

The fifteen chapters in *Digital Fundamentals* cover a comprehensive range of topics, beginning with basic digital concepts and progressing through number systems, logic gates, Boolean algebra, combinational logic, introduction to PLDs, sequential logic, implementation of sequential logic with PLDs, memories and storage, interfacing, an introduction to microprocessors and computers, and integrated circuit technologies. Further discussion of a few specific areas may be helpful.

Integrated Circuit Technologies Chapter 15 is unique in that it is intended to be used as a "floating chapter" that can be covered in whole or in part at any point in the text, or it can be completely omitted without affecting any other topics. Notices are placed throughout the text to suggest points where topics in Chapter 15 may be introduced, although it can be introduced at any time after Chapter 3. Its placement as the last chapter in the text is intended to facilitate this flexible usage, and a tab edge design provides quick and easy reference. Also, if Chapter 15 is omitted, this book can be covered without requiring a student to have a background in transistor circuits. Chapter 3 provides sufficient coverage of digi-

tal ICs for those without a transistor circuits background. For those wishing to go further into the details of integrated circuit technology, Chapter 15 provides that coverage.

Programmable Logic Devices Chapters 7 and 11 provide an introduction to the important topic of PLDs; however, this coverage can be treated as optional. Either one or both of these chapters can be omitted without affecting other topics. Chapter 7 follows the coverage of combinational logic and provides an introduction to PLDs and PLD programming as applied to combinational logic only. Chapter 11 follows the coverage of sequential logic and continues the PLD coverage from Chapter 7 with an introduction to using PLDs to implement sequential logic. A number of PLD programming languages are available; ABEL is the one used to illustrate PLD programming in this text. A brief tutorial on CUPL, another popular PLD programming language, is available in the Instructor's Resource Manual (IRM), for those who are interested. Some instructors may prefer to delay coverage of Chapter 7 until after Chapter 10 so that both PLD chapters are covered consecutively.

Microprocessors Chapter 14 provides a brief introduction to microprocessors and computers. Both hardware and software aspects are discussed. The 8086/8088 microprocessor family is used as a basic model for introducing concepts that are valid even in the latest microprocessors. The chapter covers the features of all Intel devices up through the Pentiums and introduces the Motorola microprocessor family. This chapter, of course, is not intended to provide a complete coverage of the topic as it would take one or more entire textbooks to do so. It can be used, however, as an introduction to microprocessors for students who later will take a full course devoted to the subject.

End Matter At the end of the book are appendices that contain several representative IC data sheets, a table of code conversions, and a table of powers-of-two. The appendices are followed by the Answers to Selected Odd-Numbered Problems (solutions to all end-of-chapter problems are in the IRM). A comprehensive glossary includes definitions of the key terms for each chapter in addition to other definitions. The comprehensive glossary is followed by the index.

Suggestions for Teaching with *Digital Fundamentals*

Generally, time limitations or course emphasis dictates the topics that can be covered in a term. Also, it is not uncommon to alter the sequence of certain topics as they appear in the text. The following suggestions for selective coverage, light coverage, or omission do not imply that a given topic is less important than others, but in the context of a specific program, the topic *may* not require the emphasis that the more fundamental topics do. Also, these suggestions do not necessarily reflect all possibilities for sequence alteration, selective or light coverage, or omission; in any particular program, there may be other areas that can be considered.

Suggestions for altering the sequence of chapters:

1. If you wish to cover logic gates earlier in the course, Chapter 1 can be lightly covered and Chapter 3 on logic gates can be covered before Chapter 2 on number systems, operations, and codes.
2. Coverage of Chapter 7 on PLDs can be postponed until after Chapter 10. This way, both PLD chapters (7 and 11) can be covered consecutively, if that works best in your course.
3. Chapter 15 can be covered at just about any point in the text. For example, it can be covered partially or completely after Chapter 3.

Chapters that may be considered for selective coverage:

1. Chapter 1, Introductory Digital Concepts
2. Chapter 2, Number Systems, Operations and Codes
3. Chapter 4, Boolean Algebra and Logic Simplification

4. Chapter 13, Interfacing
5. Chapter 15, Integrated Circuit Technologies

Chapters that may be considered for omission without affecting other coverage:

1. Chapter 7, Introduction to Programmable Logic Devices (Because of the growing importance of this topic, serious consideration should be given before omitting either Chapter 7 or Chapter 11.)
2. Chapter 11, Sequential Logic Applications of PLDs
3. Chapter 13, Interfacing
4. Chapter 14, Introduction to Microprocessors and Computers
5. Chapter 15, Integrated Circuit Technologies

Depending on your program, there may be additional topics that can be treated lightly or omitted. For example, the Digital System Applications sections can be omitted without affecting any other topics, or they may be assigned for extra credit or as special projects.

Acknowledgments

Many very capable people have been involved with this seventh edition of *Digital Fundamentals.* It has been completely reviewed and checked for both content and accuracy. Those at Prentice Hall who have been instrumental in moving this project through its many phases include Rex Davidson, Katie Bradford, and Scott Sambucci. They deserve much credit. My appreciation, once again to Lois Porter who has done another wonderful job of editing the manuscript. Also, thanks to Jane Lopez for the great job on the graphics art used in the text. Gary Snyder has again been my accuracy checker on this project, and I commend him for his outstanding work. In addition, Gary created the EWB circuit files for the Electronics Workbench features that are new to this edition. Last, but certainly not least, thanks to my colleague Dave Buchla for his contribution to the revision of Chapter 14, his consultations on many topics, and his thorough review of the manuscript.

As always, we depend on expert input from many users and nonusers of *Digital Fundamentals.* My thanks to the following reviewers who made many valuable suggestions and provided much constructive criticism.

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